SAMPLING AND ANALYSIS PLAN
FOR
THE DETERMINATION OF THE NATURE AND EFFECTS OF HEAVY METALS WITHIN THE WETLAND AND POND AREAS AT RICHARDSON FLAT

SITE ID: UT980952840

Richardson Flat Site
Park City, Utah

PART I – FIELD SAMPLING PLAN
PART II – QUALITY ASSURANCE PROJECT PLAN

May 13, 2003

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LIST OF ACRONYMS AND ABBREVIATIONS

AVS	Acid Volatile Sulfide
BERA	Baseline Ecological Risk Assessment
CLP	Contract Laboratory Program
COC	Contaminant of Concern
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
FTP	Field Technical Procedure
GPS	Global Positioning System
HASP	Health and Safety Plan
ICP	Inductively Coupled Plasma
ICP/MS	Inductively Coupled Plasma Mass Spectrometry
IDW	Investigation Derived Waste
LCS/LCSD	Laboratory Control Sample/Laboratory Control Sample Duplicate
MOU	Memorandum of Understanding
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NPL	National Priorities List
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
QP	Quality Procedure
RPD	Relative Percent Difference
RPM	Remedial Project Manager
TERA	Terrestrial Ecological Risk Assessment
SAP	Sampling and Analysis Plan
SEM	Simultaneously Extracted Metals
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
TAL	Target Analyte List
TOC	Total Organic Carbon
TOM	Total Organic Matter
UCL	Upper Confidence Level
USFWS	U.S. Fish & Wildlife Service
%R	Percent Recovery

1.0 INTRODUCTION

This document serves as the Sampling and Analysis Plan (SAP) for surface water, sediment, pore water, benthic macroinvertebrate, fish, and vegetation sampling, and toxicity testing of invertebrate species exposed to sediments collected from a wetland and a pond located adjacent to the Richardson Flat Site tailings impoundment. This work is being conducted as part of the Focused Remedial Investigation Feasibility Study (RIFS) that United Park City Mines Company (United Park) voluntarily agreed to conduct in the Administrative Order on Consent dated September 28, 2000.

Sampling activities conducted as part of this SAP will occur in two phases. Phase I sampling will be conducted to determine the nature and extent of contaminated sediments and surface water. Phase II sampling will consist of biological sample collection (e.g., sediment toxicity, sediment porewater, plants, macroinvertebrates and fish). The scope of Phase II sampling will be determined by results of the Phase I sampling. All sampling activities under Phase I and Phase II will be conducted following this SAP.

There have been numerous site investigations conducted at this site over the past seventeen years by the Environmental Protection Agency (EPA), Utah Division of Environmental Response & Remediation (DERR) and United Park. There have been significant remedial activities performed by United Park over the past ten years including capping the surface of the tailings with clay soils and reconstruction of the south diversion ditch. These studies and remedial activities are summarized in the Remedial Investigation SAP (RMC, 2001).

In January of 2001 EPA formed a Biological Technical Assistance Group (BTAG) to ensure that the appropriate stakeholders were represented in evaluating ecological risks presented by the site. Members of the BTAG are EPA, United Park, DERR and the United States Fish & Wildlife Service (USFWS). Members of the BTAG group reviewed and commented on the Remedial Investigation SAP that was initiated in April of 2001. In August of 2001 the group met to review EPA's draft of the Screening Ecological Risk Assessment (SERA) prepared by Syracuse Research Corporation (Syracuse, 2001), a revised draft was submitted to the group in March of 2002. This SAP has been prepared to address data gaps identified in the recent Draft SERA, March 2002.

This SAP will address data gaps identified in the recent SERA for the wetland and pond located in the northwestern portion of the site, adjacent to the main embankment. Data gaps for the on and off impoundment soils will not be addressed in this SAP, future remedial activities planned by United Park will address potential ecological risks in the soils. If United Park does not carry out the remedial activities, then United Park will work with EPA to collect data to satisfy the data gaps identified in the SERA and EPA will conduct an ecological risk assessment for those areas.

Figure 1.0 shows the geographic location of the site.

The SAP is comprised of the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (Plan) and includes the following sections:

Section 1 -Introduction
Section 2 -Site Background

Part I: Field Sampling Plan

Section 3 - Sampling Program, Rationale, and Locations
Section 4 – Field Activity Methods and Procedures

Part II: Quality Assurance Project Plan

Section 5 - Project Management
Section 6 – Quality Control Requirements
Section 7 - Assessment and Oversight
Section 8 - Data Validation and Usability
Section 9 - Measurement and Data
Section 10 - Acquisition References

Appendix A - Standard Operating Procedures
Appendix B – AEC QA/QC Documentation

1.1 Objectives

This SAP describes the collection and analyses of surface water samples, sediment (0–10 cm depth) and pore water samples, and organism tissue samples, as well as observations on benthic macroinvertebrate and plant communities. At the site, samples will be collected from the wetland area west of the main embankment and the pond area located near the terminus of the diversion ditch (Figure 1.1). The sampling effort will be conducted in two phases and will provide data to determine:

Phase I

- The nature and extent of contamination of sediment and surface water in the wetland, pond, and downgradient of the seep.
- Potential risks to terrestrial and aquatic receptors from exposures to heavy metals in surface water and sediments in the wetland and pond.
- The need for a Phase II investigation or remediation.

Phase II

- Risks to terrestrial and aquatic receptors from exposures to heavy metals in surface water, sediments, pore waters, and biota in the wetland and pond;

- The need for remediation. If unacceptable risk levels are found, the data will be used to determine preliminary remediation goals (PRGs) for the affected areas.

Metals levels in the wetland and pond sediments may present unacceptable risks to native vegetation, invertebrates, and fish, as well as wildlife. The Phase I sampling will be conducted to determine the nature and extent of contamination and to provide data for a screening risk assessment. If unacceptable risks potentially exist, the Phase I data will be used for deciding about the need for and scope of a Phase II investigation. Based on Phase I data, a decision will be made whether to conduct a Phase II risk assessment or to proceed with-remediation. If a Phase II investigation is conducted, the data will be used for a baseline ecological risk assessment and development of PRGs.

In Phase II, RMC, as advocated by the BTAG, will focus this investigation on the bioavailable fraction of metals in the sediments and their relationship with *in situ* plant and benthic macroinvertebrate community indices; plant, invertebrate, and fish tissue burdens; and laboratory sediment toxicity tests. Furthermore, sediment quality parameters such as grain size distribution, pH, moisture, total organic carbon, and nutrients will be quantified to develop predictive relationships between bulk sediment concentrations and bioavailable metals (porewater concentrations or tissue concentrations). Section 3.1 further explains how these data will be used.

Data collected as part of this SAP will build upon the existing Draft SERA. Default chemical screening values used in the SERA to evaluate metals concentration data were conservative in nature. The assessments to be conducted using Phase I and possibly Phase II will use more realistic toxicity thresholds to evaluate site metals data. Phase I chemical data will be compared with Probable Effect Level (PELs) for sediments or state water quality standards for surface water. Metals concentrations may also be compared with background data from the literature if appropriate data area available. In Phase II, site-specific data will be compared to appropriate reference site data collected as part of this SAP and used to develop site-specific toxicity thresholds. All the metals data from Phases I and II will then be compared to the site-specific toxicity thresholds to more accurately assess ecological risks at the site and to address data gaps identified in the Draft SERA (Syracuse, 2002). A food-web model will be used to estimate doses of metals in surface water (Phases I and II), food (Phase II), and sediment (Phase II) to selected wildlife receptors for comparison to toxicity reference values

1.2 Project Schedule and Deliverables

Phase I data collection will occur immediate following EPA approval of this SAP in late spring to early summer. Timing of the data collection depends upon snowmelt in the contributing watershed. The peak runoff for the diversion ditch watershed and wetland has occurred and based on site observations flowing water in the ditch and pond may not be present in another 30 days. The Phase I surface water samples will be collected as soon as EPA approves this SAP to ensure that sufficient flowing water is present in the wetland for sampling. Phase II data collection will occur following assessment of the Phase I data and depending on emergence of sufficient vegetation for sample collection, and presence of sufficient numbers of fish and aquatic macroinvertebrates for sample collection.

During Phase II, sediment, pore water, surface water, and macroinvertebrate samples for community analysis will be collected synoptically. Collection of tissue samples and the plant community observations may be done separately from other sampling depending on the availability of organisms. Deliverables will include a description of sampling activities and data when available from the laboratories in the RIFS monthly reports, and a final report describing sampling activities and summarizing the data for EPA use in the ecological risk assessment..

2.0 SITE BACKGROUND

A detailed description of the Site, including a description of the Site operational history, existing closure measures and elements, regional geology and hydrogeology and surface water is set forth in Sections 2.0 to 2.5 of the Focused RI/FS Work Plan (RMC, 2000). The study area, site history, previous site investigations, and environmental setting are summarized below.

2.1 Study Area

United Park is the current owner of a large parcel of property (the "Property"), comprising approximately 700 acres, located in Summit County, Utah (Figure 2.0). The Site included a historic mine tailings impoundment consisting of a 160-acre, geometrically closed basin formed by an earth embankment and a series of perimeter containment dikes. The tailings impoundment resulted from decades of mining and milling silver-laden ore in the area around Park City known as the Park City Mining District. The tailings impoundment is now covered by clean soils. A wetland area on the site encompasses approximately eight (8) acres, with a pond just south of the wetland that is approximately one (1) acre in surface area. Water exiting from the pond along the embankment on the south side of the tailings impoundment flows in a southeasterly to northwesterly direction in a discrete channel where it mixes with a portion of the Silver Creek flow in the northwestern corner of the wetland area.

Silver Creek forms the western boundary of the site. Several man made and natural barriers affect the flow pattern of Silver Creek near the site. Near the northwestern corner of the wetland area, Silver Creek flows into the wetland beneath the rail trail bridge where it is split by a topographical high. At that point, a portion of the flow travels to the east and mixes with the flow from the diversion ditch and a portion moves to the northeast where it converges with the

wetland drainage and exits the wetland area in a concrete box culvert under State Highway 248.

2.2 Site History

The Site has remained unused since mining and milling operations ceased in 1982. Land use in the Study Area is presently limited to onsite workers, site investigation activities, and wildlife habitat. In the wetland and pond areas, current and future land use will be limited to wildlife habitat.

Over the past fifteen years, the (EPA), the Utah Department of Environmental Quality (UDEQ) and United Park have been investigating the Site in order to characterize the Site and determine potential adverse impacts to human health and the environment associated with the Site. At the same time, United Park has been implementing a series of remedial measures at the Site intended to mitigate any potential adverse impacts on human health and the environment.

Remedial measures conducted by United Park include the following:

- Placement of clean cover soils over all exposed tailings,
- Reconstruction of the diversion ditch; and
- Construction of a fence around the property perimeter.

Evaluation of these remedial measures relative to potential site risks is presented in the conceptual site model found in Section 2.2.4 of the RIFS SAP (RMC, 2001).

This SAP is being prepared to complete relevant data gaps identified in the Draft SERA (Syracuse, 2002). The SERA concluded that the Richardson Flat Tailings site is not contributing to increased risks in Silver Creek (Syracuse, 2002). On May 14, 2002 United Park representatives met onsite with EPA and United States Fish & Wildlife Service (USFWS) representatives to discuss the scope of the data collection activities and to determine appropriate locations for the sample collection. It was determined and agreed upon at this site visit that the ecological risk assessment data collection activities would focus on the wetland, pond area and areas downgradient of the seep.

As part of the focused RI/FS process, United Park has determined that additional remedial measures will be considered as mitigation for any unacceptable risks identified after analysis of the information collected to fill data gaps identified in the draft SERA. Work completed under this SAP will address the remaining data gaps and provide pertinent data for a *focused* assessment of ecological risks. Additional remedial measures that may be considered are:

- Placement of additional clean fill over the impoundment where the existing cover is less than 12 inches. Addition of the fill will allow surface water on the impoundment to be drained to the South Diversion ditch. This will effectively manage areas where tailings may be exposed and may eventually dry up the seeps located at the toe of the embankment.

- Installation of a wedge buttress on the face of the tailings embankment; as part of this work, a

drainage system will be installed in the seep area.

- Removal of tailings in certain areas outside of the impoundment and placement of clean fill over other areas of tailings outside of the impoundment.

The above remedial measures will have a profound effect on the release mechanisms, exposure media, exposure route and ecological receptors identified in the Ecological Site Conceptual Model (ESCM) portrayed in Figure 4-1 of the Draft SERA. Specifically the following release mechanisms, exposure media, exposure routes and ecological receptors will be affected by the remedial measures:

- Wind erosion of the tailings for a short time period following active deposition of tailings in the impoundment may have impacted amphibians and reptiles as identified in the ESCM. However, the tailings have been covered for approximately 10 years and additional cover will be placed on tailings in and outside the impoundment. In limited areas east of the impoundment, tailings will be excavated and placed on the impoundment and covered with clean fill. Placement of additional cover soil will significantly reduce or eliminate exposure of amphibians and reptiles to wind blown tailings.

- In areas where the cover thickness over tailings is less than one foot in thickness, additional clean fill will be placed to increase the cover depth to one foot or greater. This will mitigate cap penetration and reduce direct contact and ingestion of soil for birds, mammals, amphibians, reptiles, plants and soil fauna, thereby reducing risks.

- Mixing of the cover soils with tailings will be mitigated by the additional cover soils placed on the entire impoundment. Impacts to sediment from mixing of cover soils with tailings have never likely been a problem at the site. Impacts to sediments in the past were the result of oversteepened side slopes on the diversion ditch channel. The angles of the sideslopes were reduced and revegetated in the early 1990's. Sediment and ecological receptor impacts will be quantified in this SAP.

- Impacts to surface water from rain and snow precipitation and interaction with tailings will be mitigated by source removal activities identified above. Surface water data from the RI indicate that for the most part the Site waters meet applicable state water quality standards. However, in the upper section of the diversion ditch zinc concentrations increase to levels above those water quality standards. Based on this and other data (depth of cover, tailings thickness, etc) collected during the RI those tailings located east of the diversion ditch near surface water monitoring stations RF-11 and RF-12 will be excavated. Other tailings found outside of the impoundment may either be excavated and/or covered with additional clean fill. However, this release mechanism and subsequent exposure routes and ecological receptors will be evaluated as outlined in this SAP.

- Any impacts to groundwater from leaching within the impoundment will be further mitigated by the additional covering of the impoundment with low permeability clean fill. The cover will be graded to direct surface water to the South Diversion Ditch. The low permeability of

the existing and additional cover along with improved surface water runoff design will substantially reduce any infiltration of water into the impoundment. This will further reduce the potential for leaching and could potentially reduce the amount of subsurface water in the impoundment. The reduction in the subsurface water may reduce and possibly eliminate the seeps located in the embankment area.

2.3 Previous Site Investigations

Previous site investigation activities have focused on nature and extent of contamination within and nearby the Study Area (Figure 2.0). United Park has submitted, on December 17, 2002, a Draft Remedial Investigation report summarizing previous data collection activities as well as data collection conducted as part of the AOC.

Previous studies to characterize the wetland area at the site have been limited to sediment, surface and groundwater data collection. In 1992, EPA's contractor, Ecology and Environment (E&E) collected four (4) sediment samples in the wetland area, two (2) surface water samples upgradient and downgradient of the wetland area and two (2) groundwater samples upgradient of the wetland area (E&E, 1993). Sediment sample data from the E&E investigation revealed elevated levels of cadmium, mercury, selenium, silver, lead, zinc, and copper.

As part of the RI, surface and groundwater data were collected for a fifteen-month period, beginning in March of 2001. These data indicate that water leaving the diversion ditch meets all applicable water quality standards. Groundwater data from piezometer RT-7 meets all applicable water quality standards, and groundwater data from monitoring well RT-12 exceeds water quality standards for aluminum, cadmium, copper, lead, antimony, and zinc. Groundwater data from monitoring well RT-11 upgradient of the wetland area exceeds water quality standards for antimony, cadmium, lead and zinc. Silver Creek surface water upgradient of the wetlands exceeds water quality standards for zinc and cadmium. Surface water in Silver Creek downgradient of the wetland exceeds water quality standards for only zinc. Surface water from the diversion ditch provides some dilution to the cadmium and zinc concentrations in the Silver Creek surface water downstream of the confluence with the diversion ditch.

The South Diversion Ditch that flows through the pond is a stormwater and groundwater interception ditch that was constructed to divert storm and groundwater from entering the tailings impoundment. The ditch was constructed in the early to mid 1970's by Park City Ventures (PCV), however the ditch was constructed with oversteepend bank slopes in tailings over most of its' length. In 1993 United Park reconstructed the ditch laying back the oversteepend bank slopes and covering the slopes and some tailings in the ditch bottom. Since 1993 surface water quality has improved over much of the diversion ditch. The upper reach of the ditch does contain zinc concentrations in surface water that exceed water quality standards. However, the lower portion of the ditch, from RF-5 to RF-6-2 meets water quality standards (RMC, 2002). The pond is located between these two surface water sample locations.

There have been no studies conducted to date on vegetative types or densities within these areas. Nor have there been any studies conducted on the species composition or population demographics of terrestrial and aquatic biota.

2.4 Environmental Setting

The Study Area is roughly 6,570 feet above mean sea level. The study area is located in the Basin and Range physiographic province, approximately 40 miles northwest of Salt Lake City, Utah.

The Study Area is characterized by a cool, dry, semi-arid climate. Long-term meteorological observations have not been kept at the Site. The two nearest meteorological data stations are located in Park City, Utah which is located 500 feet higher in elevation three miles to the southeast in the Wasatch Mountains, and Kamas, Utah located at a similar elevation to the Site and nine miles to the east. The annual precipitation for the Site likely falls in-between the values for the two sites. Annual precipitation at Park City is 21.44 inches of water with an annual average high temperature of 56.3 degrees and an annual average low temperature of 30.8 degrees. Annual precipitation at Kamas is 17.27 inches of water per year with an average annual low temperature of 29.0 degrees and an average annual high temperature of 58.7 degrees (www.wrc.dri.edu, 2001).

Long-term wind data have not been kept in the vicinity of the Site. The prevailing wind direction is from the northwest to southeast as determined by the EPA contractor Ecology and Environment during an air monitoring assessment conducted in 1986 (E&E, 1987).

More comprehensive descriptions of the environmental settings and lists of references are available in the Focused Remedial Investigation Workplan, Sampling and Analysis Plan (RMC, 2000 and 2001, respectively) and the Draft SERA (Syracuse, 2002).

PART I: FIELD SAMPLING PLAN

3.0 SAMPLING PROGRAM, RATIONALE, AND LOCATIONS

The Field Sampling Plan (FSP) for this investigation has been developed to provide rationale and procedures for the collection of samples to assess levels of metals contamination at specified locations in conjunction with plant and invertebrate community indices, bioaccumulation studies, and laboratory sediment toxicity tests.

3.1 Experimental Design and Sampling Rationale

The general objective of this sampling effort is to determine the nature and extent of contamination and to collect data needed for the evaluation of hazards posed to terrestrial and aquatic receptors by metals in surface water, sediment and sediment pore water, and biota in the pond and wetland. Results from this sampling effort may be used to further evaluate the fate and transport of metals in surface water and in the sediments found in the wetland and pond areas. Fate and transport anaylses have been performed for the site contaminants as presented in the Focused RI submitted to EPA in December 2002.

To optimize predictive capabilities of effects on potential receptors (e.g., development of PRGs) Phase II data will be collected in a manner to quantify bioavailable metal concentrations in sediments (i.e., porewater) and in surface water along with those factors that influence bioavailability (e.g., pH, nutrients, and organic matter). The concentration and form of metals in aquatic systems control metal availability and toxicity. The most toxic form of metals is generally the dissolved free metal ion and the least toxic form is associated with particles, which is the reason concentrations in filtered water samples are compared to ambient water quality criteria to assess risk. The dissolved fraction of the metals, such as found in sediment porewater, can be further broken down into species such as free metal ions, sorbed to colloidal material, and complexed with both organic and inorganic ligands. Data collected on the chemistry of filtered surface water and porewater (e.g., metal concentration, matrix ion concentrations, pH, and DOC) can be further used in a chemical equilibrium model such as EPA's MINTEQ, to calculate the concentrations of metal species, and in particular the free metal ion. The calculated concentrations can then be used to identify possible causes of observed toxicity.

Phase II measures of exposure will also include plant, invertebrate, and fish tissue concentrations of metals. These tissue data will be used in food chain models to assess exposure of and risk to wildlife species dependent on food resources in the wetland and pond. Direct effect measures in Phase II will include invertebrate toxicity testing of sediments, benthic macroinvertebrate community analysis, and wetland plant community analysis.

3.2 Sample Media and Parameters

All sampling described below is required to achieve the project objectives. The focus of sample collection activities proposed in this SAP is evaluation of the following environmental media in the wetland area west of the main embankment, in the ponded area at the terminus of the diversion ditch, and in corresponding habitats at reference sites. Table 3.0 summarizes the

sample media, parameters to be measured, and how these data will be used in the risk characterization.

Table 3.0. Sampling Objectives and Risk Characterization Approach

Media/Parameters	Sampling and Analysis Objectives	Risk Characterization Approach
Surface water: Dissolved metals and water quality parameters (Phases I and II) Total metals (Phases I and II)	- Determine exposure of aquatic invertebrates, fish, and wildlife receptors (Phases I and II). - Determine potential bioavailability of metals (Phases I and II). - Estimate dose and risk of metals to wildlife ingesting water (Phases I and II).	- Compare dissolved metals concentrations with Utah state water quality standards to estimate risk to water column invertebrates and fish (Phase I). - Compare exposure of wildlife from ingestion of contaminated drinking water to toxicity reference values (Phases I and II).
Sediment: Total metals and compositional properties (Phases I and II)	- Determine nature and extent of contaminated sediments (Phase I). - Determine exposure of benthic macroinvertebrates, fish, wildlife, and wetland plants (Phase II). - Determine the contribution of metals in sediments, if any, to the metal loading in surface water (Phase I).	- Compare metals concentrations to PELs (Phase I) - Develop exposure-response relationships (Phase II). - Interpret sediment chemistry data relative to toxicity test and macroinvertebrate data in the Triad assessment (Phase II). - Compare exposure of wildlife from ingestion of contaminated sediment and food to toxicity reference values (Phase II).
Pore water (sediment): Metals and water quality (Phase II)	- Determine exposure of benthic macroinvertebrates (Phase II). - Determine potential bioavailability of metals (Phase II). - Determine if the sediments are a source or sink for metals in the surface water (Phase II).	- Interpret pore water chemistry data relative to toxicity test data and macroinvertebrate data in the Triad assessment (Phase II). - Use data in a chemical equilibrium model (e.g., MINTEQ) to calculate the concentrations of metal species and free metal ion (Phases I and II).

Table 3.0. Sampling Objectives and Risk Characterization Approach (cont.)

Media/Parameters	Sampling objectives	Risk Characterization Approach
Sediment: Toxicity test responses (Phase II)	- Evaluate exposure-response relationships for aquatic macroinvertebrates (Phase II). - Estimate risk to aquatic macroinvertebrates (Phase II).	- Determine statistically significant toxicity relative to reference area sediments (and > 25 % response) and interpret as part of Triad assessment (Phase II).
Sediment: Benthic macroinvertebrate community indices (Phase II)	- Evaluate exposure-response relationships for aquatic macroinvertebrates (Phase II). - Estimate risk to aquatic macroinvertebrates (Phase II).	- Determine statistically significant differences in macroinvertebrate indices between site stations and reference area stations and interpret as part of Triad assessment (Phase II).
Sediment and surface water: Wetland plant community indices	- Evaluate exposure-response relationships for plants (Phase II). - Estimate risk to plants (Phase II).	- Determine statistically significant differences in plant community indices between site stations and reference area stations and interpret compositional differences relative to literature (Phase II).
Tissue: Vegetation, invertebrate, and fish	- Estimate exposure of wildlife receptors (Phase II). - Evaluate uptake of metals from the sediment, surface water and pore water (Phase II). - Determine bioaccumulation of metals (Phase II).	- Compare exposure of wildlife from ingestion of contaminated sediment and food to toxicity reference values (Phase II).

Section 4.5 (and Table 4.1) discusses in detail the field sampling and data collection. Metals data will be used to estimate exposure of ecological receptors, while biological data are used as measures of response. The metals that will be analyzed for this assessment will mirror the COPC's identified in the Draft SERA.

3.3 Sampling Locations

Figure 3.0 shows the locations of the sampling stations at the site. Sampling locations were determined during the site visit with EPA and USFWS representatives on May 14, 2002 and during a conference call on April 29, 2003 with the BTAG group.

Nature and extent sampling of sediment and surface water will be conducted prior to sampling of other media discussed in this SAP. Approximately twenty (seventeen in the wetland and three in the pond) sediment and six surface water samples will be collected during Phase I. The sediment samples will be collected to better characterize the nature and extent of contamination in the wetland and to establish a concentration gradient. The concentration gradient will be used to determine the optimal locations of biological stations (e.g. for sediment toxicity samples) for potentially establishing exposure-response relationships. It is expected that the nature and extent samples will help minimize the number of biological samples collected as well. The surface water sampling will be collected at the earliest opportunity and likely with the nature and extent sampling for sediments. During Phase I, four surface water samples will collocated with sediment sample locations in the wetland and two surface water samples will be collocated with sediment sample locations in the pond.

Thirteen sampling sites were selected in the wetland prior to the convergence with the Silver Creek water and four sampling sites (RFB-SD1, RFB-SD2, RFB-SD3 and RFB-SD6) were selected after the convergence with Silver Creek. Data from the four sample sites in the area where Silver Creek converges with the wetland flow will be used to evaluate possible ecological impacts in the wetland. These data will not be used to evaluate impacts to Silver Creek. Impacts to Silver Creek are being evaluated under the Upper Silver Creek Watershed Stakeholder Group. Data from the thirteen sample sites located in the wetland, prior to the convergence with Silver Creek, will be used to evaluate impacts to the wetland from the Richardson Flat Tailings impoundment.

Three sediment sampling locations were selected in the pond area as shown on Figure 3.0. The pond is relatively small with an area of one (1) acre. The pond sampling locations were selected to represent an average of the pond surface water and sediment characteristics.

In addition to the on-site stations, two stations will be sampled during Phase II in reference areas located in mineralized areas without mining activities: one in a wetland habitat with physical properties approximately similar to the on-site wetland, and one in a pond habitat. The reference site data will include sediment chemistry, sediment toxicity test results, and benthic macroinvertebrate community. Selection of appropriate reference sites will be conducted as part of the habitat characterization of the site (refer to Section 4.2) and with concurrence from EPA, USFWS and UDEQ representatives. One sample location will be located at each reference site.

Based on the results of the nature and extent sampling in Phase I, additional media will be sampled during Phase II to provide data for the Baseline Ecological Risk Assessment (BERA). Sampling stations for all elements of this investigation (i.e., the surface water assessment, the sediment Triad, plant community analysis, and tissue sampling) will be collocated at the locations determined by the metals concentration gradients determined in Phase I. During Phase II, discrete sediment samples will be collected for analysis of metals and ancillary parameters in porewater and sediment, and for sediment toxicity testing and macroinvertebrate community analysis. Grid sampling for the plant community analysis will be centered on points collocated with the media samples. Tissue samples for some biota (i.e., macroinvertebrates and fish) will be composited across stations to represent an average for wetland and an average for pond habitats

at both the site and the reference area. This approach will be used to mimic the exposure regime of wildlife receptors, which range across areas at least as big as the wetland and the pond.

4.0 FIELD ACTIVITY METHODS AND PROCEDURES

The following field activities and procedures will be employed for this project (see Section 5.7 for laboratory analytical methods):

- Site Mobilization
- Surveying and Habitat Characterization
- Mobilization of Equipment, Supplies, and Containers
- Equipment Decontamination
- Field Sample Collection
  - — Surface Water Sampling (Phase I and Phase II)
  - — Sediment Sampling (Phases I and II)
    - ⇒ Nature and extent sampling (Phase I) for Physical-Chemical Analysis
    - ⇒ Chemical and physical characterization for Triad and correlation with porewater (Phase II)
    - ⇒ Sediment Toxicity Testing Sampling (Phase II)
    - ⇒ Benthic Macroinvertebrate Community Survey (Phase II)
    - ⇒ Benthic Macroinvertebrate Tissue Sampling for Metals Analysis (Phase II)
  - — Pore Water Sampling (Phase II)
  - — Plant Tissue Sampling for Metals Analysis (Phase II)
  - — Fish Tissue Sampling for Metals Analysis (Phase II); and
  - — Plant Community Survey (Phase II)
- Investigation-Derived Waste.

Referenced SOPs are included in Appendix A..

4.1 Site Mobilization

RMC will identify and provide all necessary personnel, equipment and materials for mobilization and demobilization to and from the site for the purpose of conducting the sampling events. Equipment mobilization also entails ordering and purchasing of equipment and supplies. A complete inventory of available equipment and supplies will be conducted prior to initiating the field activities and any additional required equipment or supplies will be obtained.

4.2 Surveying and Habitat Characterization

Global positioning system (GPS) receivers will be used to locate all sampling locations in the field.

During Phase I, a habitat characterization will be conducted concurrent with sampling activities. This will include a physical characterization of the site and a characterization of the water quality. The physical characterization will include documentation of land use, a description Silver Creek, the diversion ditch, and pond; and documentation of the riparian and wetland vegetation. Waterbody parameters such as width, depth, flow, and substrate will also be recorded. The water quality characterization will include field and laboratory measurements of temperature, pH, dissolved oxygen, and turbidity (refer to Table 4.1). The information collected during the habitat characterization will provide information regarding the ability of the waterbodies and wetland to support a healthy ecological community, and regarding the presence of stressors to the ecosystem.

A vegetation covertype map will be developed as part of the habitat characterization for the site and surrounding vicinity. Qualitative observations of wildlife usage of the site will also be recorded. This information will be used in the development of the conceptual site model (i.e., identification of exposure pathways and ecological receptors) for the ecological risk assessment.

As part of the habitat characterization, reference sites will be selected. The reference areas will consist of one wetland habitat and one pond habitat. Reference areas will be selected that are in non-impacted, mineralized areas that have similar physical conditions to the onsite wetland and pond, such as soil type, hydrology, topography, and vegetative community.

4.3 Equipment, Supplies and Containers

Equipment and supplies necessary to support the field activities are summarized in Table 4.0. This table separates field items into the following categories: sampling, health and safety, equipment and personal decontamination, and general field operations.

Sample containers and any required preservatives will be supplied by the laboratories or purchased from approved vendors. All sample containers will be pre-cleaned and traceable to the facility that performed the cleaning. Sample containers will not be cleaned in the field. Surface and pore water containers will be triple rinsed in the field with sample media prior to filling.

4.4 Equipment Decontamination

All sampling equipment will be decontaminated prior to use at each station and between media types. Equipment decontamination procedures outlined in *Sampling Equipment Decontamination* (RMC SOP 6 provided in Appendix A) will be used in this sampling program. Equipment decontamination will be performed by placing the sampling equipment in a bucket filled with deionized (DI) water and non-phosphate soap, and removing any visible residual material from the sampling equipment with a brush. Any residual soap or debris will be removed

by pouring DI water over the equipment. Sampling equipment will then be double rinsed with deionized water. Upon completion of this procedure, all equipment will be air dried and stored in a "clean" vessel or wrapped with foil until ready for use. Disposable, one use, sampling equipment will be used to the extent possible.

4.5 Field Sampling and Data Collection

Table 4.1 provides a summary of the analyses that will be conducted during Phase I and Phase II of the field investigation. The sample volumes, containers, and preservation requirements for these samples are specified in the QAPP (Part II). Samples for chemical analysis will be identified as follows: surface water samples will be designated with SW identifier, sediment with a SD, sediment pore water with a PW, vegetation with a VEG identifier, benthic macroinvertebrates with a BMI identifier, and fish with a FI identifier. Sediment bioassay samples will be identified with SD-BIO, benthic macroinvertebrate samples for community analysis with a BMI-COM, and vegetation community stations with a VEG-COM identifier. The methods that will be used to collect the samples are discussed below.

4.5.1. Surface Water Grab Samples

Surface water samples will be collected at a minimum of four (4) locations in the wetland area and two locations in the pond area as depicted on Figure 3.0, and at two reference stations in corresponding habitats. The on-site sampling locations were selected during the May 2002 site visit by EPA and USFWS representatives and also based on data uncertainties identified in the Draft SERA.

The samples will be collected according to the SOP, *Surface Water Sampling* (RMC SOP 1), presented in Appendix A. Field analytical parameters and procedures are shown on Table 4.1 of this SAP. Surface water samples for dissolved metals analyses will be filtered in the field prior to sample preservation (RMC SOP 1, Appendix A). Sampling locations will be logged with a Global Positioning Survey (GPS) unit.

4.5.2. Sediment and Benthic Macroinvertebrate Samples

During Phase I, sediment samples will be collected at seventeen (17) locations in the wetland and three (3) locations in the pond. Samples for analysis of sediment physical-chemical parameters, toxicity, benthic macroinvertebrate tissue chemistry, and benthic macroinvertebrate community structure will not be collected during Phase I. If a decision is made to proceed with Phase II, these additional samples will be collected after the nature and extent sampling is completed. The biologic sample locations will be determined based on the results of the nature and extent sampling. During Phase II ecological sampling locations will be determine by data collected during the Phase I sample event.

An Ekman grab sampler will be used to collect sediment during both Phase I and Phase II. During Phase I, the material from the 0–10 cm horizon will be collected at each station for chemical analyses. During Phase II, material from the 0–10 cm horizon at each station will be collected for chemical analyses, toxicity testing, and macroinvertebrate tissue analyses. For

collection of macroinvertebrates for community analysis, the contents of entire grab samples will be retained. If plant roots or other material in the sediments precludes use of a grab sampler, sediments will be collected by using a drive rod check-valve corer or other similar coring equipment. The 0–10 cm depth horizon designated for each analysis would then be exuded from each core. For collection of benthic community samples, the sampling device should be consistent among stations, so a reconnaissance of stations will be needed to assess which device is most appropriate. Procedures for sampling are described in the SOPs entitled *Surface Sediment Sampling Using an Ekman Grab Sampler* (Exponent SOP SD-05); and *Sediment Coring Using a Drive Rod Check-Valve Corer* (Exponent SOP SD-10) provided in Appendix A.

Each sediment sample will be evaluated for acceptability based on the following criteria:

- Overlying water is present and not excessively turbid
- The sediment surface is relatively undisturbed
- The planned penetration depth of the grab sampler or push corer is achieved.

If a sample fails to meet any of the acceptance criteria, it will be rejected and discarded away from the station. Multiple cores or surface grabs may need to be collected from each station to provide sufficient material for all specified analyses.

4.5.2.1. Sediment Chemistry and Toxicity Testing Samples

Sediment samples for toxicity testing will not be collected during the Phase I nature and extent sampling, they will be collected during the Phase II biological testing conducted after the nature and extent sampling is completed. The 0-10 cm depth horizons collected from each sediment sample for sediment chemistry and toxicity testing will be transferred into a stainless-steel bowl. The sample(s) from a given station will be mixed with large stainless-steel spoons to achieve a uniform texture and color. The homogenized sample will be subsampled and transferred to the appropriate sample containers (Table 4.1). Large artifacts such as rocks and twigs will be removed from the sample during homogenization. The relative amount and types of material removed will be noted in the field logbook.

The samples will be placed in glass or polyethylene containers and kept in coolers on ice (4 degrees Celsius) until transfer to a refrigerator at the laboratory. The samples will be stored in glass or polyethylene containers and kept at 4 degrees Celsius. All samples will be analyzed as bulk samples.

4.5.2.2. Benthic Macroinvertebrate Samples

The Phase II benthic macroinvertebrate community assessment and tissue analyses investigation consists of the following tasks:

- **Macroinvertebrate Community Analysis**—Grab sampling will be performed to evaluate benthic community composition, including taxa abundance and distribution. Ten (10) on-site sampling stations and two (2) reference stations will be co-located with the other sediment

and surface water sampling stations. Care will be taken to collect benthic macroinvertebrate samples from locations that were not disturbed by previous sample collection activities.

- **Macroinvertebrate Tissue Sampling**—Sampling and analyses of metals concentrations and percent moisture in dominant macroinvertebrate taxa (e.g., amphipods and chironomids) will be completed to evaluate metals bioaccumulation and potential for transfer to higher trophic levels. Ten (10) on-site sampling stations and two (2) reference station will be co-located with the other sediment and surface water sampling stations. Tissue samples for macroinvertebrates will be composited across stations to represent an average for wetland and an average for pond habitats at both the site and the reference area. This approach will be used to mimic the exposure regime of wildlife receptors, which range across areas at least as big as the wetland and the pond.

Sampling to characterize benthic community composition will be completed using an Ekman grab sampler (preferred) or a coring device. Each grab sample will be evaluated for acceptability based on the criteria listed above. Five replicate grab samples of surface sediments (0-10 cm) will be collected from each of the 12 sampling locations. If it is necessary to use a coring device instead of a grab sampler (in order to cut through plant material in the sediment), 15 replicate cores (0–10 cm depth horizon) will be collected at each station. Whichever sampling device is chosen for the investigation, the same device should be used consistently among all stations.

Each replicate sample, consisting of sediment and the overlying water, will be strained through a sieve (600 μm) to isolate benthic organisms. Retained material from each grab sample will be transferred to an appropriate sample container and preserved in the field for later sorting and identification in a taxonomic laboratory. Detailed sampling procedures for the collection of grab samples and processing of macroinvertebrate samples are presented in the SOPs, *Surface Sediment Sampling Using an Ekman Grab Sampler*; and *Sediment Coring Using a Drive Rod Check-Valve Corer* (Exponent SOPs SD-05 and SD-10) (Appendix A).

Sampling to collect macroinvertebrate tissues for metals analyses will be completed using a grab sampler (Ekman) or corer to collect surface sediments (approximately 0–10 cm depth) from 10 on-site locations and 2 reference locations. The number of samples required to collect tissues for constituent analyses will vary at each location according to the abundance of amphipods and chironomids in the surface sediment. Sediment collection at each location will continue until the minimum mass requirement for tissue analyses (30-50 g organisms) is obtained at each location, or until a reasonable effort has been expended to obtain the sample. Sediments and overlying water from each grab sample will be strained through an appropriately sized screen (600 μm) with gentle streams of water. The contents of each sieve will be combined into a large collection container, covered with water, and sorted at the field laboratory to isolate the target macroinvertebrate sample groups. Target organisms will be collected and preserved on ice for subsequent processing and transfer to the analytical laboratory. Detailed sampling procedures for collecting and processing macroinvertebrate tissues and sediment samples are included in the SOPs, *Benthic Macroinvertebrate Sampling using a Grab Sampler* (Exponent SOP BI-12) and, *Aquatic Invertebrate Processing Procedures* (Exponent SOP BI-11) (Appendix A).

4.5.3. Sediment Porewater

During Phase II, sediment porewater will be collected using a micro push point at selected locations selected after the nature and extent sampling is conducted. Sample locations will be determined based on the results of the nature and extent sampling (Figure 3.0). A porewater sample will be collected assuming there is a positive flux of groundwater to the wetland or pond at each station. Porewater samples will be collected following methods in the porewater sampling SOP, *Porewater Sampling from a Micro Push Point or Mini Piezometer* (SOP #SRC-OGDEN-01) (Appendix A). Sediment porewater samples for dissolved metals analyses will be filtered in the field prior to sample preservation (RMC SOP 1, Appendix A). Some modifications to the porewater sampling method may be required based on the sediment particle size and other sediment characteristics encountered in the field at the time of sampling. Any deviations from the SOP that may be required to ensure sample representativeness will be documented in the field logbook. In addition, porewater will be collected by centrifuging a sediment sample split in the laboratory. The bulk sediment chemisty, porewater, and toxicity samples are taken as splits of the same homogenized sample collected during Phase II

4.5.4. Plant Tissue Samples for Metals Analysis

Plant tissue samples in Phase II will be collocated with the sediment sampling stations for the Triad analyses. The number and location of these stations will be determined after the Phase I nature and extent sampling is conducted. Sampling methods will follow Exponent SOP BI-13, *Vegetation Sampling* and Exponent SOP BI-01, *Decontamination of Equipment—Tissue* (Appendix A). Methods not addressed in these SOPs will follow EPA/ERT SOP #2037, *Terrestrial Plant Community Sampling* and Exponent BI-13, Vegetation Sampling (Appendix A).

A single dominant plant species that serves as a food source for terrestrial receptors will be targeted for tissue sampling. The dominant forage plant species will be determined by conducting a qualitative survey of the plant species in the on-site wetland and pond. A qualified botanist will record visual cover estimates at each sampling location. The forage species with the highest average cover within each plant community will be selected for plant tissue collection. In the pond, plant tissue samples will be collected from plants nearest the bank assuming an emergent species is the plant species selected for analysis. If the species selected for analysis is submerged aquatic vegetation or if emergent species are not present in the pond, then a submerged vegetation species will be sampled to represent the plant species for the pond.

A 1 m^2 PVC tube quadrant frame will be used to delimit each of the individual sampling points. Tissue from several individual plants of the dominant herbaceous plant species may have to be collected at each location to obtain enough sample volume. Vegetation sampling locations will be co-located with the surface water and sediment sampling sites. Herbaceous plant tissue sampling will involve the collection of the aboveground biomass only, utilizing a pair of stainless steel scissors.

The wetland plant community likely features sedges, rushes, willows, and various other woody scrub/shrub species. For this community type, a larger 10 m^2 sampling plot will be utilized (2.5 meters by 4 meters). If these plots are dominated (in terms of percent cover) by woody shrubs (such as Rocky Mtn. willow), then branches will be cut from the dominant shrub species using pruning shears. The branch including its leaves, buds and fruiting structures (if present) will comprise the tissue sample. Several plants within the large plots will be sampled in order to provide a representative mass of plant tissue from the dominant species. If the plot is dominated by herbaceous vegetation, such as sedges, then the dominant species will be collected in the same manner as herbaceous matter was collected as described above (i.e., by cutting aboveground shoot mass with stainless steel scissors).

One-gallon, resealable plastic bags will be used to contain samples of the dominant vegetation from each location. The samples will be placed on ice in coolers, transported to the laboratory and transferred to a refrigerator at 4 degrees Celsius until analysis.

4.5.5. Fish Tissue Samples for Metals Analysis

Fish tissue samples will be collected in Phase II after the completion of the Phase I nature and extent sampling. Composite samples of the two most abundant species of forage fishes will be collected from the wetland and pond on-site (Figure 3.0) and from two stations at the reference sites. Fish tissue samples will be composited across stations to represent an average for wetland and an average for pond habitats at both the site and the reference area. This approach will be used to mimic the exposure regime of wildlife receptors, which ranges across areas at least as big as the wetland and the pond.

The species targeted for sampling will be those that may potentially serve as a food resource for piscivorous birds and mammals. Because data are not available on the fish community composition at the site and reference areas, a reconnaissance survey will be conducted to provide data for selection of target species for the investigation.

The wetland, the pond, and the reference sites will each be considered a "station area" for fish sampling because fish move among specific locations designated for other sample analyses. At each of the four station areas (i.e., site wetland, site pond, reference wetland, and reference pond), 15 individuals of each of the two dominant fish species will be collected for analyses. Only fish from 2-4 inches in total length will be retained for analyses in order to target the size classes available to a wide range of predators and to limit variability of the data due to any age/size-related factors. Species will be maintained separately for analysis. Three composite samples of five individual fish of each species will be formed at each station. The individuals comprising each composite sample will be selected so that the average total length of fish does not differ significantly between replicate composite samples (by species).

Depending on the physical characteristics of the sampling locations, fish will be collected using electrofishing units, beach seines, minnow traps, or a combination of techniques. Procedures for operation of each type of equipment are summarized below. Detailed procedures are provided in NYSDEC (1999a) and in *Fish Collection Procedures Using an Electroshocker* (Exponent SOP BI-04) (Appendix A).

The electrofishing unit sends an electric current through the water, temporarily stunning the fish. The stunned fish are then collected with a scap net. Because the electrofishing unit generates electric current, several precautions must be taken to avoid electrocution during sampling. Electrofishing will only be conducted by technicians who are familiar with the appropriate safety procedures, and all equipment will be maintained and operated according to the manufacturer's instructions. All persons in the sampling crew must wear hip boots or chest waders as a safety precaution.

Beach seines are manually dragged along the shore to collect fish in shallow waters. Minnow traps are passive collection devices (i.e., fish enter the traps but cannot escape) that must be anchored in place and set for several hours.

The following information will be recorded as soon as possible after sample collection for all fish collected:

- Weight and total length measurements
- Reproductive state
- Presence of grossly visible abnormalities.

Procedures for determining length and weight of fish are described in NYSDEC (1999a) and in *Fish Processing Procedures* (Exponent SOP BI-08) (Appendix A).

After length and weight measurements have been made, fish will be double-bagged in two plastic Ziploc® bags containing a sample identification label. Fish for composite samples will be bagged together in two plastic Ziploc® bags to represent one sample for analytical purposes.

At the field office, samples will be packaged on ice in coolers and shipped by local courier or overnight delivery service to the analytical laboratory for chemical analysis. The analytical laboratory performing chemical analyses on whole-body samples will be responsible for sample homogenization and (if appropriate) transferring sample aliquots required for chemical analysis to the appropriate laboratories.

4.6 Plant Community Metrics

Plant community observations will be made in Phase II after the completion of the Phase I nature and extent sampling. Plant community observations will be made in accordance with EPA/ERT SOP #2037, *Terrestrial Plant Community Sampling* (Appendix A). A qualitative assessment of the type and extent of the wetland habitat will be conducted by a qualified botanist. Prior to collecting sediment and plant tissue samples from the plots established in upland and riparian areas in Phase II, a botanist will record data based on visual observations within each plot. These data will include a record of signs of vegetative stress (wilting, browning, stunted growth, chlorosis, grazing evidence, etc.), and habitat characteristics (spatial arrangement of species, foliage density, light penetration characteristics, moisture availability, slope aspect, sediment characteristics, etc.).

A quantitative survey of the wetland plant community will be conducted at the 12 co-located sediment and surface water stations (Figure 3.0). The botanist will collect data that will yield measures of plant diversity and community similarity, including: species composition, species-specific cover and frequency, species richness, and species evenness in the sample plots at each station. A 1 m^2 PVC tube quadrat frame will be used to delimit each of the individual sampling plots at each station. Three replicate samples will be taken at each station for species counts. The quadrat will be randomly placed by an individual standing at the station and throwing the quadrat over his/her shoulder. Species composition and total species richness measurements will also be made at each station by identifying species within a 10 m^2 sampling plot centered on the station.

4.7 Investigation-Derived Waste

Investigation-derived waste (IDW) generated during this study will be handled in accordance with OERR Directive 9345.3-02 *Management of Investigation-Derived Wastes During Site Inspections* (EPA, 1991). Collecting only the volume of material needed to satisfy laboratory analytical requirements will minimize the generation of IDW. Any excess material will be discarded at the sample collection point.

PART II: QUALITY ASSURANCE PROJECT PLAN

5.0 PROJECT MANAGEMENT

The QAPP (Part II of this SAP) for the Richardson Flat ecological risk assessment has been developed in accordance with EPA QA/R-5 guidance for preparing QAPPs (EPA, 1997). This section covers the basic area of project management, including the project organization, background and purpose, project description, quality objectives and criteria, special training, and documentation and records.

5.1 Project Organization

Organization and responsibilities specific to this investigation are discussed in this section. Laboratory services will be provided by an EPA approved laboratory, which will analyze the surface water, sediment, sediment-pore water, vegetation and biological tissue samples for metals.

For this data collection effort, key management personnel are as follows:

Individual	Role/Responsibility
Kerry Gee	United Park Project Manager
Jim Fricke	RMC Site Manager
Linda Ziccardi	Exponent Ecotoxicologist
Jim Christiansen	EPA Remedial Project Manager
Dale Hoff	EPA Regional Ecotoxicologist
Dan Wall	EPA/USFWS Liaison
Mohammad Slam	UDERR
Gary Colgan	CH2M Hill – QA Official

The management team consists of United Park personnel with assistance from RMC and other environmental consulting firms as needed. Figure 5.0 shows the chain-of-command for the project managers, engineers, and quality assurance officials responsible for managing the Richardson Flat Tailings Site Ecological Risk Assessment SAP.

United Park's environmental Project Manager for the Site is Kerry Gee, who will be responsible for all project management and communication with the regulatory agencies. Jim Fricke of RMC, Salt Lake City, Utah, leads United Park's environmental project consultant team and will be the Site Manager, who will be responsible for implementation of the SAP. Todd Leeds, of RMC, is the Field Manager who will be responsible for all field activities related to this document. Wesley McDonald, RMC, is the Site Safety Officer, who will be responsible for visitor sign in and ensure that all site visitors comply with the HASP.

The EPA Project Coordinator is Jim Christiansen, Region VIII, Denver, Colorado. The Utah Department of Environmental Remediation and Response (UDERR) Project Manager is Muhammad Slam. The EPA Project Coordinator and the UDERR Project Manager work

cooperatively to oversee the work being performed at the Richardson Flat site.

Mr. Gee, as Project Manager, is responsible for the overall management and coordination of the following activities:

- Coordination with EPA/UDERR regarding the status of the project;
- Providing oversight of the subcontractors;
- Reviewing monthly status reports;
- Supervising production and review of deliverables;
- Tracking work progress against planned budgets and schedules;
- Informing EPA/UDERR of changes in the Workplan, SAP, HASP and/or other project documents;
- Notifying EPA/UDERR immediately of significant problems affecting the quality of data or the ability to meet project objectives;
- Procuring subcontractors to provide sampling and analytical support;
- Providing oversight of report preparation;
- Organizing and conducting a field planning meeting.

Mr. Fricke, as the Site Manager, is responsible for the following:

- Preparing monthly status reports;
- Coordinating with the laboratory regarding the analytical, data validation, and Quality Assurance/Quality Control (QA/QC) issues related to sample analysis;
- Reviewing analytical results and deliverables from subcontractors;
- Incorporating changes in the Workplan, SAP, HASP, and/or other project documents;
- Scheduling personnel and material resources;
- Implementing field aspects of the investigation, including this SAP and other project documents;
- Implementing the QC measures specified in the QAPP in this and other project documents;
- Implementing corrective actions resulting from staff observations, QA/QC surveillance, and /or QA audits;
- Providing oversight of data management;
- Coordinating and overseeing the efforts of the subcontractors providing sampling and analytical support;
- Scheduling and conducting field work;
- Notifying the subcontract analytical laboratory of scheduled sample shipments and coordinating work activities;
- Gathering sampling equipment and field logbooks, and confirming required sample containers and preservatives.
- Maintaining proper chain-of-custody forms and shipping of samples to the analytical laboratory during sampling events;
- Ensuring that sampling is conducted in accordance with procedures detailed in this SAP and that the quantity and location of all samples meet the requirements of the SAP; and
- Identifying problems at the field team level; resolving difficulties in consultation with the QA/QC staff; implementing and documenting corrective action procedures at the field team

level; and providing communication between the field team and United Park management.

The roles and responsibilities of other field team members will be to assist the Site Manager with sampling activities, sample handling, and overall documentation. Oversight activities including sampling to be conducted by EPA's on-site contractor will be coordinated between the EPA Project Coordinator and United Park's Project Manager. EPA's on-site contractor and the Site or Field manager will work together to coordinate sampling efforts.

5.2 Quality Assurance/Quality Control Organization

The Quality Assurance Official (QAO) is Gary Colgan, with CH2M Hill, who is responsible for the quality assurance/quality control of the data that are generated during implementation of the SAP. Mr. Colgan will report any QA/QC problems to the Site Manager. As the QAO, he will be responsible for the following:

- Reviewing and approving project specific plans;
- Directing the overall project QA/QC program;
- Maintaining QA/QC oversight of the project;
- Reviewing QA/QC sections in project reports, as applicable;
- Reviewing QA/QC procedures applicable to this SAP;
- Auditing selected activities of this project performed by RMC and subcontractors, as necessary;
- Initiating, reviewing, and following up on response actions to address QA/QC problems, as necessary;
- Consulting with the Site Manager and/or Project Manager, as needed, on appropriate QA/QC measures and corrective actions;
- Arranging performance audits of measurement activities, as necessary; and
- Providing written reports on QA/QC activity to the Project Manager and Site Manager.

5.3 Background and Purpose

Site background information for the Richardson Flat Site is provided in Section 2.0 of this SAP. The purpose and objectives of the work assignment are discussed in Section 1.1 of this SAP. The purpose of this QAPP is to provide guidance to ensure that all environmentally related data collection procedures and measurements are scientifically sound and of known, acceptable, and documented quality conducted in accordance with the requirements of the project.

5.4 Project Description

The QAPP addresses field work, data collection and laboratory analyses performed for this work assignment. Detailed project descriptions are outlined in the FSP sections above.

5.5 Data Quality Objectives (DQOs) and Criteria for Measurement

This section provides internal means for control and review so that environmentally-related measurements and data collected in this study are of known quality. The subsections below describe the DQOs (Section 5.5.1) and data measurement objectives (Section 5.5.2).

5.5.1. Data Quality Objectives

The DQO process is a series of planning steps based on the scientific method that are designed to ensure that the type, quantity, and quality of environmental data used in decision-making are appropriate for the intended purpose. The EPA has issued guidelines to help data users develop site-specific DQOs (EPA, 1994b). The DQO process is intended to:

- Clarify the study objective;
- Define the most appropriate type of data to collect;
- Determine the most appropriate conditions from which to collect the data; and
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the design.

The goal of the DQO process is to help assure that data of sufficient quality are obtained to support remedial response decisions, reduce overall costs of data sampling and analysis activities, and accelerate project planning and implementation. Data Quality Objectives are summarized in Table 5.0.

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The process also ensures that the resources required to generate the data are justified. The DQO process consists of seven steps, of which the output from each step influences the choices that will be made later in the process. These steps include:

Step 1: State the problem;
Step 2: Identify the decision;
Step 3: Identify the inputs to the decision;
Step 4: Define the study boundaries;
Step 5: Develop a decision rule;
Step 6: Specify tolerable limits on decision errors; and
Step 7: Optimize the design.

During the first six steps of the process, the planning team develops decision performance criteria (DQOs) that will be used to develop the data collection design. The final step of the process involves developing the data collection design based on the DQOs. A brief discussion of these steps and their application to this project is provided below.

Step 1: State the Problem

The purpose of this step is to describe the problem to be studied so that the focus of the study will be unambiguous. The wetland, pond, and areas downgradient from the seep currently have no remedial action planned to directly reduce potential exposure of aquatic and riparian receptors to metals. However, the nature and extent of risks to receptors contacting these areas will be assessed in the sampling program. If the estimated risks are considered unacceptable, remediation strategies will be developed for these areas. The Draft SERA utilized conservative risk estimates. The sampling specified in this SAP will be conducted to provide site-specific data for a more realistic risk assessment and for development of PRGs.

Step 2: Identify the Decision

This step identifies what questions the study will attempt to resolve and what actions may result. The principal study question for these areas is: "Are adverse effects observable in terrestrial and aquatic receptors at this site?" The question to be answered using the data is: "Are the concentrations of metals in the sediments correlated with uptake metals in vegetation and aquatic species, and do these levels correlate with flora and fauna demographics and sediment toxicity on the site?"

Step 3: Identify the Inputs to the Decision

The purpose of this step is to identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement. Based on the study questions, the following information is required:

- The concentrations of dissolved metals in the surface water;
- The concentrations of metals in the bulk sediments;
- The bioavailable concentrations of metals in the sediments (i.e., porewater);
- The concentrations of metals in the wetland vegetation;
- The concentrations of metals in benthic macroinvertebrate tissue;
- The concentrations of metals in fish tissue;
- The toxicity of bioavailable metals in the wetland and pond sediments to invertebrates;
- Plant and benthic community indices in the wetland and pond areas.

Step 4: Define the Boundaries of the Study

This step defines the spatial boundaries of the study. The entire project will be performed within the wetland and pond area as shown on Figure 3.0.

Step 5: Develop a Decision Rule

The Phase I decision process consists of the following steps:

1) Assess whether the data are usable based on the data validation and evaluation processes. If yes, continue; if no, devise a second sampling phase to collect usable data.

2) Compare surface water concentrations of metals with state water quality standards and sediment concentrations of metals with PELs. If no excedances are found, conclude that no further study is needed and remediation is unnecessary. If excedances are found, conclude that further investigation or remediation is needed. The information on the number and extent of excedances will be used to determine whether to conduct Phase II sampling and proceed with the BERA or to go directly to a remedial planning phase. In either of these cases, proceed with step 3.

3) Assess if bulk metals concentrations in surface water or sediments are greater than reference area concentrations. It may be valuable to define reference site distributions from chemical data from the literature for a suite of sites within areas with geologic conditions similar to the Richardson Flats site. If insufficient data from mineralogical enriched areas are available, then background data from USGS databases may provide perspective. The comparison of chemical concentrations between site and reference will be done as follows:

   a) A statistical distribtutional approach should be used to compare means (if the data are normally or log-normally distributed) or distributions (nonparametric test). If they are different, then proceed to step b.

   b) The 90th percentile of the reference site(s) distribution (if there are enough data from the literature) will be used as a cut-off for defining whether a given station on the site exceeds reference.

   c) Summarize results for use in the BERA or in remedial planning.

The Phase II decision process consists of the following steps:

1) Assess whether the data are usable based on the data validation and evaluation processes. If yes, continue; if no, devise a second sampling phase to collect usable data.

2) Assess whether there is significant toxicity or risk to the selected aquatic and terrestrial ecological receptors as part of a BERA. If yes, go to step 3; if no, no further action.

3) Assess if bulk metals concentrations in surface water or sediments correlate with biological response measures (e.g., sediment toxicity test endpoints, abundances of macroinvertebrate taxa, relative abundances of wetland plant species). If yes, go to step 5; if no, go to step 4.

4) Assess if metals concentrations in sediment porewater correlate with vegetation or benthic community indices, or significant toxicity in invertebrates. If yes, go to step 5, if no, go to step 6.

5) Assess if bioavailable metals concentrations in surface water or sediments correlate with concentrations in vegetation, benthos, or fish. If yes or no, go to step 6.

6) Evaluate exposure-response relationships and compare site data to reference site data to determine acceptable levels of bioavailable metals concentrations in sediments (bioavailable PRGs).

8) Evaluate exposure-response relationships and compare site data to reference site data to determine acceptable levels of total metals concentrations in sediments (total PRGs).

The Phase II decision process may be modified based on the Phase II sampling and analysis design, which depends partly on the results of Phase I.

Step 6: Specify Tolerable Limits on Decision Errors

Error margins are generally higher for sediment samples in comparison to water samples. Concentration variability of 35% or more between duplicate sediment samples indicates that data should be used with caution.

Laboratory QC sample recoveries will be reviewed to determine if they are within acceptable limits. These recovery units are established by the analytical method. Matrix spikes and laboratory control samples will be conducted in accordance with the validation procedures.

The acceptable limits on decision errors should be smallest (i.e., have the lowest probability of error) for cases where one has the greatest concern for decision errors. This means that if one type of error is more serious than another, then its acceptable limits should be smaller (more restrictive). In addition, the limits on decision errors are usually highest (high probability of error can be tolerated) near the action level, since the consequences of decision errors are generally less severe as the action level is approached (EPA, 1994b). The acceptable limits of decision errors for this study will be that analytical results (the 95% upper confidence level [UCL] for surficial concentrations) must be exactly equal to or below background concentrations to be excluded from further action consideration.

Step 7: Optimize the Design for Obtaining Data

This step identifies a resource-effective data collection design for generating data that are expected to satisfy the DQOs. The data collection design (sampling program) is described in detail in the FSP, Part 1 of this SAP. Metal concentration data are not available with any reasonable density within the chosen areas. Given the relatively small land area under study (approximately 8.4 acres) the number of samples was selected based on spatial distribution.

5.5.2. Data Measurement Objectives

Based on the information provided on the DQOs, all samples will be analyzed using EPA methods and other standard analytical techniques. Every reasonable attempt will be made to obtain a complete set of usable analytical data. If a measurement cannot be obtained or is unusable for any reason, the effect of the missing data will be evaluated by the QAO and Site Manager. Table 4.1 summarizes the analytical methods and data measurement objectives for analyses that will be conducted in the field investigations.

5.6 Quality Assurance Guidance

The field QA program has been designed in accordance with EPA's *Guidance for the Data Quality Objectives Process* (EPA, 1994b), and the EPA's *Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA, 1997).

5.6.1. Precision, Accuracy, Representativeness, Completeness, and Comparability Criteria

Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameters are indicators of data quality. PARCC goals are established for the site characterization to aid in assessing data quality, as discussed in the following paragraphs:

Precision. The precision of a measurement is an expression of mutual agreement among individual measurements of the same property taken under prescribed similar conditions. Precision is quantitative and most often expressed in terms of relative percent difference (RPD). Precision of reported results is a function of inherent field-related variability plus laboratory analytical variability. Various measures of precision exist, depending upon "prescribed similar conditions." Field duplicate samples (1 duplicate / 20 samples) will be collected to provide a measure of the contribution to overall variability of field-related sources. Contribution of laboratory-related sources to overall variability is measured through various laboratory QC samples. The acceptable RPD limits for field duplicates are less than 35% for soil, water and sediments. Chemical analytical data will be validated for precision using field duplicates, laboratory duplicates, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory control sample/laboratory control sample duplicates (LCS/LCSDs), as applicable.

Accuracy. Accuracy is the degree of agreement of a measurement with an accepted reference or true value, and is a measure of the bias in a system. Accuracy is quantitative and usually expressed as the percent recovery (%R) of a sample result. Ideally, it is desirable that the reported concentration equals the actual concentration present in the sample. Acceptable QC limits for %R are 75% to 125% for LCS/LCSDs, method-defined for surrogates, and laboratory-defined for MS/MSDs. Chemical analytical data will be validated for accuracy using surrogates, MS/MSDs, and LCS/LCSDs, as applicable.

Representativeness. Representativeness expresses the degree to which sample data accurately and precisely represent (a) a characteristic of a population, (b) parameter variations at a sampling point, and/or (c) an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling plan and the absence of cross-contamination. Good representativeness will be achieved through: (a) careful, informed selection of sampling sites, (b) selection of testing parameters and methods that adequately define and characterize the extent of possible contamination and meet the required parameter reporting limits, (c) proper gathering and handling of samples to avoid interference and prevent contamination and loss, and (d) collection of a sufficient number of samples to allow characterization.

Representativeness is a consideration that will be employed during all sample location and collection efforts and will be assessed qualitatively by reviewing field procedures and reviewing actual sampling locations versus planned locations.

Completeness. Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Evaluating the PARCC parameters will assess usability. Those data that are validated and need no qualification, or are qualified as estimated data, are considered usable. Rejected data are not considered usable. Completeness will be calculated following data evaluation. For this work, a completeness goal of 90% is projected for each analytical test. If this goal is not met, additional sampling may be necessary to adequately achieve project objectives.

Comparability. Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Where appropriate, the results of analyses obtained will be compared with the results obtained in previous studies. Standard EPA analytical methods and QC will be used to ensure comparability of results with other analyses performed in a similar manner. Comparability is a qualitative parameter and cannot be assessed using QC samples.

5.6.1 Field Measurements

Field measurements specified in Table 4.1 will be conducted during the investigation. All procedures recommended by the manufacturer will be followed in calibrating and operating the instruments. Analytical methods, reporting limits, holding times, and QC analyses are discussed below.

5.7 Laboratory Analytical Methods

Analytical methods, with corresponding laboratory reporting limits (LRLs) are specified on Table 4.1. Laboratories with established protocols and quality assurance procedures that meet or exceed applicable EPA guidelines will analyze samples by following these methods. Samples will be analyzed using EPA-approved or recommended methods when available and will include all associated QA/QC procedures recommended in each method.

Samples will be submitted to American Environmental Consultants Laboratory (AEC) in Salt Lake City, Utah. AEC is certified with the State of Utah. Appendix B contains AEC's QA/QC manual, and certification letters from the Utah Department of Health and Division Bureau of Laboratory Improvement. If another lab performs analyses, it must meet the following criteria and submit all QA documentation to the EPA for approval as described above:

- Demonstrated ability to achieve the required detection limits,
- Certified by the State of Utah, and
- Established internal QA/QC program.

If contradictions between the laboratory QA/QC manuals or other documents are identified, information in this SAP supersedes all other documents.

For sediment samples, the laboratory shall assume that the entire sample submitted for analysis is representative material. To avoid substance losses, any overlying water in sediment samples received from the field will be mixed into the sample before removal of a subsample for analysis.

5.7.1. General Sediment and Water Analysis

5.7.1.1 Sediment

Sediment samples will be analyzed for general parameters, consisting of particle size distribution, total organic carbon (TOC), moisture content, and pH (Table 4.1). In addition, the sediment samples will be analyzed for metals including aluminum, silver, selenium, antimony, cadmium, lead, arsenic, nickel, thallium, vanadium, zinc, manganese, chromium, copper, iron and mercury (Table 4.1).

Analysis for sediment particle size will follow Plumb (1981) with minor modifications. Each sediment sample will be separated into two particle-size fractions (>63 μm [sand] and <63 μm [silt and clay] only) using standard wet-sieve analyses. The material retained on the sieve will be

rinsed into a pre-cleaned, tared beaker, dried at 90°C, and weighed. Percent of total dry weight for each of the two size fractions will be calculated. The weight of the sand fraction will be added to the weight of the silt/clay fraction and compared to the starting weight for each sample.

5.7.1.2 Surface Water and Sediment Porewater

Samples of surface water and sediment pore water will be analyzed for the analytical parameters noted in Table 4.1.

5.7.2 Bioavailable Metals Analysis

Bioavailable metals will be measured by analyzing surface water and sediment pore water samples for the paramters specified in Table 4.1.

Surface water samples will be analyzed for dissolved metals by filtering water samples through a 0.45 μm membrane filter in the field. Porewater samples will also be filtered after collection.

5.7.3 Total Metals

Sediment and organism tissue samples will be analyzed for total metals.

5.7.3.1 Bulk Sediment

Total metals will be measured in bulk sediment samples according to methods specified in Table 4.1. The samples will be analyzed by EPA method 6010B (ICP/AES) or by EPA method 8020 (ICP/MS), depending on the availability of laboratory instrumentation. Sample digestion will be completed by EPA method 3050B, using acids as appropriate for the determinative method.

5.7.4 Biological Tissue Analysis

Benthic macroinvertebrate, fish, and plant tissue samples will be digested and analyzed for the same metals as bottom sediments (Table 4.1). Metals in tissue samples will be analyzed by the same methods specified for sediments.

5.7.5 Sediment Toxicity Testing

Chronic toxicity of wetland and pond sediment to benthic organisms will be measured using EPA Test Methods (U.S. EPA 2000). The test will use the amphipod *Hyalella azteca* in 28-day exposures to bulk sediments. The test medium will be collected from the surface to 10 cm (i.e., the "biologically active zone") of sediment as described in Section 4.5.2.1 above. Both negative controls (i.e., clean sediment) and positive controls (i.e., reference toxicant) will be used to ensure that the test organisms are suitably healthy and responsive for testing.

Ten on-site sediment samples and two reference sediment samples will be submitted to the laboratory for toxicity testing. Endpoints for the tests are:

- *Hyalella* test
  - Percent survival on Day 28
  - Growth (as length) on Day 28
  - Reproduction (number of eggs per female) on Day 28.

QA/QC procedures for the toxicity tests include use of positive and negative controls and measurement of water quality conditions (i.e., conductivity, hardness, pH, alkalinity, ammonia, sulfide, temperature, and dissolved oxygen) in each test chamber during the 10-day exposure period. The positive controls use exposure to a reference toxicant such as cadmium chloride to ensure that the test organisms are suitably sensitive for testing (i.e., they respond to the reference toxicant in a dose-responsive manner and the LC50 values are within the expected range based on past studies). The negative controls use exposure to the culture medium to ensure that the test organisms are suitably healthy for testing (e.g., they are not overly stressed from handling, culturing, or other nontoxicant factors). Criteria for test acceptability will follow recommendations of U.S. EPA (2000)

5.7.6 Macroinvertebrate Community Analysis

Sorting and identification of aquatic macroinvertebrates will be conducted by qualified taxonomy personnel from Utah State University (USU) located in Logan, Utah. USU personnel have conducted similar studies in the Silver Creek watershed in the vicinity of Richardson Flat. Qualified taxonomists will make all taxonomic identifications, and a project reference collection will be established. Identifications will be made to the lowest practical taxonomic level. All samples will be archived for the duration of the project. The following information will be reported by the taxonomic laboratory to allow a complete review of the benthic data:

- The number of individuals of each taxon found in each sample
- The biomass (nearest 0.1 g dry weight) of each major taxonomic group in each sample
- The sorting efficiency for each sample and the identity of all samples that required sorting.

6.0 QUALITY CONTROL REQUIREMENTS

Quality control will include collecting field duplicates at a rate of 10 percent of the sample load for each sample type, and ensuring that the laboratory runs matrix spike/matrix spike duplicates at a rate of five percent of the sample load for each sample type. The field duplicates will be submitted "blind" to the sample laboratory, i.e., they will be given a separate sample identification number from the environmental sample, unidentifiable to the laboratory, as described above. Field duplicates will be run for the same analytical suite as the environmental samples.

Samples for preparation of matrix spikes and laboratory duplicates will be selected at random by the laboratory. Separate samples do not need to be collected in the field. The laboratory will perform and report all analyses under QA/QC procedures that include the results of method blanks, laboratory control samples, matrix spikes, and laboratory duplicates. Additional method-specific quality control procedures such as interference check samples, serial dilution, and

internal standards will be used as specified for each analytical method in SW-846 (U.S. EPA 2003).

Due to the nature of the contaminants at this site, ambient, equipment and trip blanks will not be collected.

6.1 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All instruments and equipment will be regularly tested, inspected, and maintained according to manufacturers' instructions. Field equipment will be tested and inspected daily before use. Any equipment found to be not functioning properly will be repaired or replaced. Laboratory equipment will be tested, inspected and maintained in accordance with the laboratory QA/QC manual and manufacturers' recommendations.

6.2 Instrument Calibration & Frequency

6.2.1 Field Instruments

RMC will follow the manufacturer's specifications to calibrate any field equipment prior to each use. These manufacturers specifications are included in RMC's SOP's (Appendix A). A record of the calibration will be kept in the field logbook.

6.2.2 Laboratory Equipment

Procedures and schedules for the calibration of laboratory equipment are described in the appropriate SW-846 and EPA methods, and in the laboratory's Quality Assurance Plan. These procedures and schedules will be followed for all laboratory work.

6.2.3 Data Management

Data from AEC Laboratory will be submitted to United Park and RMC in both hard copy and electronic form. To avoid transcription errors, report tables will be prepared directly from the electronic submittals.

7.0 ASSESSMENT / OVERSIGHT

7.1 Assessments and Response Actions

This section describes the number, frequency, and type of assessment activities needed for this project. Assessments coordinated by the Project QA Officer will include: (1) a readiness review prior to initiating each major phase of field work; (2) surveillance during representative phases of the project; (3) a technical systems audit (TSA) conducted toward the end of the first week of field work; and (4) a data quality assessment (DQA).

The readiness review will be conducted with both the field staff and analytical laboratories as a technical check to determine if the staff, subcontractors, equipment, and record keeping systems

are in place to start work in accordance with this QAPP. At the review, the QA Officer will review the project objectives, methodologies, record keeping requirements, and schedule with the field team and laboratories to make sure they are familiar and prepared to meet project requirements. The QA Officer will make sure all systems are ready before field work is initiated.

Surveillance will include weekly reviews of project progress and compliance with QAPP requirements. The project QA Officer will visit the field teams at the Site and observe their work habits and review project records. Based on the surveillance results, the QA Officer may propose corrective actions or changes to the field methods to the Project Manager.

A TSA will be conducted about halfway through the field portion of the project. The TSA is a thorough and systematic on-site qualitative audit where facilities, equipment, personnel, training, procedures, and record keeping and is conducted to determine conformance to the QAPP.

The DQA will be conducted to determine whether the data meet the assumptions that the DQOs and data collection design were developed under and whether the total error in the data are tolerable. This assessment activity will include complete data verification and validation as described in Section 5.0. *Guidance for the Data Quality Assessment Process* (EPA QA/G-9) will be consulted.

The QA Officer will report results of the assessment activities directly to the Project Manager who, with the assistance of the QA Officer, will be responsible for implementing any necessary corrective actions. The occurrence and resolution of major quality issues identified during assessment activities will be documented in memorandum to UPCM, the EPA Project Manager Jim Christiansen, and the UDEQ Project Manager Muhammad Slam.

8.0 DATA VALIDATION AND USABILITY

8.1 Data Review, Validation & Verification Requirements

The data validation process evaluates whether the specific requirements for an intended use have been fulfilled and ensures that the results conform to the users needs. The data validation process develops the QC acceptance criteria or performance criteria.

Data verification confirms that the requirements of the specified sampling and analytical methods were followed. This process involves reviewing the results of sampling and analysis to determine conformance with the QC requirements described for the project. The data verification process ensures the accuracy of data by using validated methods and protocols, and is often based on comparison with reference standards.

Requirements and methods for data validation and verification are listed in Tables 8.0 and 8.1.

8.2 Validation & Verification Methods

Data will be reviewed to ensure that the requirements stated in Table 4.1 and 8.0 were met. Data

validation and verification will be conducted using the methods described in Table 8.1. Superfund's working definitions for data verification and validation are as follows:

> Data Validation: A consistent, systematic process that determines whether the data have been collected in accordance to the specification as listed in the approved QAPP. The process is independent of data validation and is conducted at various levels both internal and external to the data generator (laboratory).
>
> Data Validation: An evaluation of the technical usability of the verified data with respect to planned objectives. Data validation is performed external to the data generator (laboratory), using a defined set of performance criteria to a body of data in the evaluation process. This may include checks on some or all of the calculations in the data set and reconstruction of some or all final reported data from initial laboratory data (e.g., chromatograms, instrument printouts). It is in the data validation process that data qualifiers for each verified data are evaluated. It extends beyond the analytical method to protocols or QAPPs to address the overall technical usability of the generated data.

One hundred percent (100%) of the data will be validated according to Table 8.1 requirements by the Project QA Officer or a subcontractor experienced in conducting this type of data verification. Data will be reviewed as it is received, continuously throughout the project. If problems are uncovered as a result of the validation effort, the QA Officer and Project Manager will be immediately notified. The QA Officer or Project Manager will discuss possible corrective actions with the laboratory prior to implementation. The Project Manager will immediately notify EPA and UDEQ of any data verification or validation issues that may affect the success of the project.

Any deviations from the analytical control limits specified in Table 4.1 and 8.1 will be evaluated in terms of their effect on the data usability. Data usability will be assessed using the National Functional Guidelines for Data Review (Inorganic & Organic, February 1994). The completeness goal for the project is 90 percent valid data.

The results of the data validation and verification will be summarized in a Data Review Report, to be prepared after the completion of sampling and analysis activities at the site.

8.3 Reconciliation with Data Quality Objectives

The data validation and verification results will be compared to the DQOs stated in Table 5.0 and with the PARCC parameters described in Table 8.0. This evaluation will summarize the QA/QC performance by PARCC criteria including completeness calculations expressing the percent complete of valid data compared to the total number of samples collected. The result of the data validation and verification will be summarized in the Data Review Report described above.

8.4 Reporting Limits

The reporting limits provided in Table 4.1 are the minimum levels that the laboratory will report analytical results without a qualifier when an analyte is detected. The laboratory can typically detect analytes at concentrations of up to an order of magnitude lower than the reporting limits; in this case, when a positive detection is less than the reporting limit, the value may be reported and qualified as an estimated concentration.

8.5 Holding Times

Holding times are storage times allowed between sample collection and sample extraction or analysis (depending on whether the holding time is an extraction or analytical holding time) when the designated preservation and storage techniques are employed. Sample preservation and holding time requirements for samples collected in the field investigations are summarized in Table 4.1. Holding times for soil samples for analysis of metals is 180 days (30 days for mercury) with no preservative. Total organic matter, DOC, nutrients, and pH samples should be analyzed as soon as possible following collection. All samples will be cooled and stored at 4 degrees Celsius ±2 degrees Celsius until the requested analyses are performed.

8.6 Quality Control Analyses

To provide an external check of the quality of the field procedures and laboratory analyses, two types of QC samples will be collected and analyzed. Field replicate (duplicate) samples will be collected in order to distinguish between variability in results introduced by the field and sample handling prior to receipt by the laboratory and variability introduced by the laboratory procedures. These samples will be analyzed for metals. An equipment rinsate blank will be collected and analyzed for metals to assess potential contamination of sampling equipment for the analytes of interest. The collection and number of field QC samples that will be analyzed in this field program are discussed in Section 5.6 of this QAPP

In addition to the external QA/QC controls, the laboratory maintains internal QA procedures. Internal QC samples will include laboratory blanks (i.e., method blanks, preparation blanks), laboratory duplicates, MS/MSDs, and LCS/LCSDs, as discussed in Appendix B.

8.7 Special Training Requirements

The only special training required for this investigation is the health and safety training, as described in the RI HASP (RMC, 2001) for the project.

9.0 MEASUREMENT AND DATA ACQUISITION

This section covers sample process design, sampling methods requirements, handling and custody, analytical methods, QC, equipment maintenance, instrument calibration, supply acceptance, nondirect measurements, and data management.

9.1 Sample Process Design

The general goal of the field investigation is to verify and quantify the presence or absence of arsenic and metals in surface sediments. Sections 3.0 and 4.0 of this SAP describe the field sampling plan.

9.2 Sampling Methods Requirements

Sampling equipment, containers, and overall field management are described below.

9.2.1 Sampling Equipment and Preparation

Sampling equipment required for the field program for environmental sampling, health and safety monitoring, equipment and personal decontamination, and general field operations are presented in Table 4.0 of this SAP.

Field preparatory activities include review of SOPs, procurement of field equipment, laboratory coordination, confirmation of site access, as well as a field planning meeting attended by field personnel and QA staff. Site mobilization is described in Section 4.0 of this SAP.

9.2.2 Sample Containers

Sediment samples for laboratory analysis will be collected in 8-ounce wide-mouth glass jars. Plant tissue samples and sediment samples for toxicity tests will be collected in 1-gallon, self-sealing plastic bags. Surface water samples for metals analysis will be collected in 1-liter poly bottles. Containers for the environmental samples that will be collected during the field program are specified in Table 4.1.

9.2.3 Sample Collection

Samples collected during this field program will consist of surface sediment, surface water, benthic macroinvertebrates, fish, vegetation, and QC samples. All sample collection procedures are outlined in Section 4.5 and SOPs in Appendix A. The following SOPs apply to all applicable sample collection activities:

RMC SOP 1, Surface Water Sampling and General Water Sample Handling
RMC SOP 5, Sample Handling, Documentation and Shipping
RMC SOP 6, Sampling Equipment Decontamination
SRC-OGDEN SOP 01, Porewater Sampling from a Micro Push Point or Mini Piezometer
EPA/ERT #2037, Terrestrial Plant Community Sampling,
Procedures for Benthic Macroinvertebrate Taxonomy and Enumeration (To be provided by the laboratory conducting this analysis)
Exponent SOP BI-01, Decontamination of Equipment—Tissue
Exponent SOP BI-04, Fish Collection Procedures using an Electroshocker

Exponent SOP BI-05, Fish Collection Procedures using a Seine Net
Exponent SOP BI-08, Fish Processing Procedures
Exponent SOP BI-11, Aquatic Invertebrate Processing Procedures
Exponent SOP BI-12, Benthic Macroinvertebrate Sampling using a Grab Sampler
Exponent SOP BI-13, Vegetation Sampling
Exponent SOP SD-05, Surface Sediment Sampling using an Ekman Grab Sampler
Exponent SOP SD-10, Sediment Coring Using a Drive Rod Check-Valve Corer

9.3 Sample Handling and Custody Requirements

Custody and documentation for field and laboratory work are described below, followed by a discussion of corrections to documentation.

9.3.1. Field Sample Custody and Documentation

Samples for TAL metals submitted through the CLP will be labeled in accordance with the *Sampler's Guide to the Contract Laboratory Program* (EPA, 1990). Samples analyzed through laboratories coordinated by RMC will be labeled using procedures established in RMC SOP 5 (Sample Handling and Documentation). Sample labels will include the site name, sample identification number, and required analyses. Additional sample collection information including the date and time of sample collection, and sampler's initials will be recorded on the labels in permanent black ink markers or pens at the time of sample collection.

9.3.2. Chain-of-Custody Requirements

A Chain-of-Custody Record will be completed at the time of sample collection. An EPA Chain-of-Custody Record will be used for samples submitted for analysis through the CLP, and an SAIC Chain-of-Custody Record or one provided by the laboratory will be used for non-CLP samples. Field personnel will record the sample identification number, sampling date and time, sample matrix, sampler's initials, and analytical requirements in permanent black ink pens. Completed Chain-of Custody Records will be reviewed for completeness by the Field Operations Manager prior to sample shipment. Samples will be relinquished under the Chain-of-Custody Procedures identified in EPA's *Sampler's Guide to the Contract Laboratory Program* (1990) and RMC SOP 5 (Sample Handling and Documentation).

9.3.3. Sample Packaging and Shipping

Samples will be hand delivered to the laboratory.

After the sample containers are sufficiently packaged, the inner plastic bag lining the cooler will be sealed around the samples by twisting the top and securely taping the bag closed. Ice (sealed in bags) will be placed between the inner and outer plastic bags, with the latter taped and sealed closed. A temperature blank will be included with each cooler in order to record the cooler temperature upon receipt by the laboratory.

9.3.4. Field Logbooks and Records

Documentation of field activities will be conducted in accordance with RMC SOP 5 (Sample Handling and Documentation). The field sampling team will maintain a comprehensive field logbook that includes notes regarding instruments used, site and weather conditions, GPS coordinates, vegetative community observations, sample time, sampler's name, analytical parameters, and sample handling and chain of custody. The field activities will be recorded in bound, sequentially numbered, waterproof notebooks. All entries will be will be made in permanent black ink, will be clear, objective, and legible. Representative photographs will also be taken of field activities and sample locations, and a description will be recorded in the logbook. Photographs will be taken at each plant sampling location in the Phase II investigation. The Field Operations Manager is responsible for maintenance and document control of the field logbooks.

9.3.5. Laboratory Custody Procedures and Documentation

Laboratory custody procedures are provided in each laboratory's QA Manual. Upon receipt at the laboratory, each sample shipment will be inspected to assess the condition of the shipping cooler and the individual samples. This inspection will include measuring the temperature of the cooler (if cooling is required) to document that the temperature of the samples is within the acceptable criteria and verifying sample integrity. The enclosed chain-of-custody records will be cross-referenced with all of the samples in the shipment. Laboratory personnel will then sign these chain-of-custody records and copies provided to EPA Quality Assurance Coordinator will be placed in the project file. The sample custodian may continue the chain-of-custody record process by assigning a unique laboratory number to each sample on receipt. This number, if assigned, will identify the sample through all further handling. It is the laboratory's responsibility to maintain internal logbooks and records throughout sample preparation, analysis, data reporting, and disposal.

9.3.6. Corrections To and Deviations From Documentation

For the logbooks, a single strikeout initialed and dated is required for documentation changes. The correct information should be entered in close proximity to the erroneous entry. All deviations from the guiding documents will be recorded in the logbook(s).

9.4 Analytical Methods Requirements

Samples collected during this project will be analyzed in accordance with standard EPA and/or nationally-accepted analytical procedures. The selected EPA-approved laboratories will adhere to all applicable QC requirements established by the subcontract. The methods to be used for chemical analysis and the associated holding times are shown in Table 4.1.

9.5 Quality Control Requirements

Field, laboratory, and internal office QC are discussed below.

9.5.1. Field Quality Control Samples

Quality control checks will be employed during field activities to ensure the quality and integrity of sample collection. Both field duplicate and equipment rinsate QC samples will be collected in the field and shipped to the appropriate laboratory for analysis, as described in Section 5.10.

All field duplicates will be collected as close as possible to the same point in time and space as the primary field sample. Field duplicate sample will be prepared at a frequency of 20 percent of all sediment samples obtained during the study, and will be handled and analyzed in the same manner as the environmental samples.

9.5.2. Laboratory Quality Control Samples

The approved EPA contract laboratory(ies) will follow all laboratory QC checks, as defined in the analytical methods listed in Section 5.6. Quality control data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination. Each type of laboratory-based QC will be analyzed at a rate of 5 percent or one per batch (a batch is a group of up to 20 samples analyzed together), whichever is more frequent. Results of the QC will be included in the QC package and QC samples may consist of laboratory blanks, laboratory duplicates, MS/MSDs, and/or LCS/LCSDs, whichever are applicable, and any other method-required QC samples.

Blank samples will be analyzed to assess possible contamination so that corrective measures may be taken, if necessary. Duplicate samples are aliquots of a single sample that are split on arrival at the laboratory or upon analysis. Results obtained for two replicates that are split in a controlled laboratory environment may be used to assess laboratory precision of the analysis. MS/MSD and LCS/LCSD analyses may be used to determine both precision and accuracy.

Both normal and QC samples will be spiked with surrogate compounds, when applicable, and a percent recovery will be calculated for each surrogate.

9.5.3. Internal Quality Control Checks

Internal QC checks will be conducted throughout the project to evaluate the performance of the project team during data generation. All internal QC will be conducted in accordance with EPA CLP methods and requirements.

9.6 Equipment Maintenance Procedures

All laboratory equipment will be maintained in accordance with each laboratory's SOPs.

9.7 Instrument Calibration Procedures and Frequency

Calibration of field and laboratory instruments is addressed in the following subsections.

9.7.1. Field Equipment

Field instruments used in the field investigation consist of GPS units used to measure sample station coordinates and pH meters used to measure water samples. The GPS receivers require no special calibration procedure, and all measurements will be conducted according to the manufacturer's suggested procedures. There are few areas with overhead cover in the study area, and little difficulty is expected in acquiring adequate satellite signals.

Calibration of the pH meter will be performed prior to use in the field on at least a daily basis. In all cases, the pH meter will be calibrated and operated according to instructions supplied with the instrument, and calibration information will be recorded in the field log or instrument log. Solutions used for the calibration of pH meters will be within the expiration date supplied on the bottle label.

9.7.2. Laboratory Equipment

Calibration of laboratory equipment will be based on written procedures approved by laboratory management. Instruments and equipment will be initially calibrated and subsequently continuously calibrated at approved intervals, as specified by either the manufacturer or more updated requirements (e.g., methodology requirements). Calibration standards used as reference standards will be traceable to the EPA, National Institute of Standards and Technology, or another nationally-recognized reference standard source.

Records of initial calibration, continuing calibration and verification, repair, and replacement will be filed and maintained by the laboratory. Calibration records will be filed and maintained at the laboratory location where the work is performed and may be required to be included in data reporting packages.

9.8 Acceptance Requirements for Supplies

Prior to acceptance, all supplies and consumables will be inspected to ensure that they are in satisfactory condition and free of defects.

9.9 Non-Direct Measurement Data Acquisition Requirements

Non-direct measurement data include information from site reconnaissances, literature searches, and interviews. The acceptance criteria for such data include a review by someone other than the author. Any measurement data included in information obtained from the above-referenced sources will determine further action at the Richardson Flat site only to the extent that those data can be verified.

9.10 Data Management

Sample results and QC data will be delivered to the EPA RPM as an electronic data deliverable (EDD) in addition to a hard-copied data package. Electronic copies of all project deliverables,

including graphics, are maintained by project number. Electronic files are routinely backed up and archived.

10.0 REFERENCES

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APPENDIX A

STANDARD OPERATING PROCEDURES

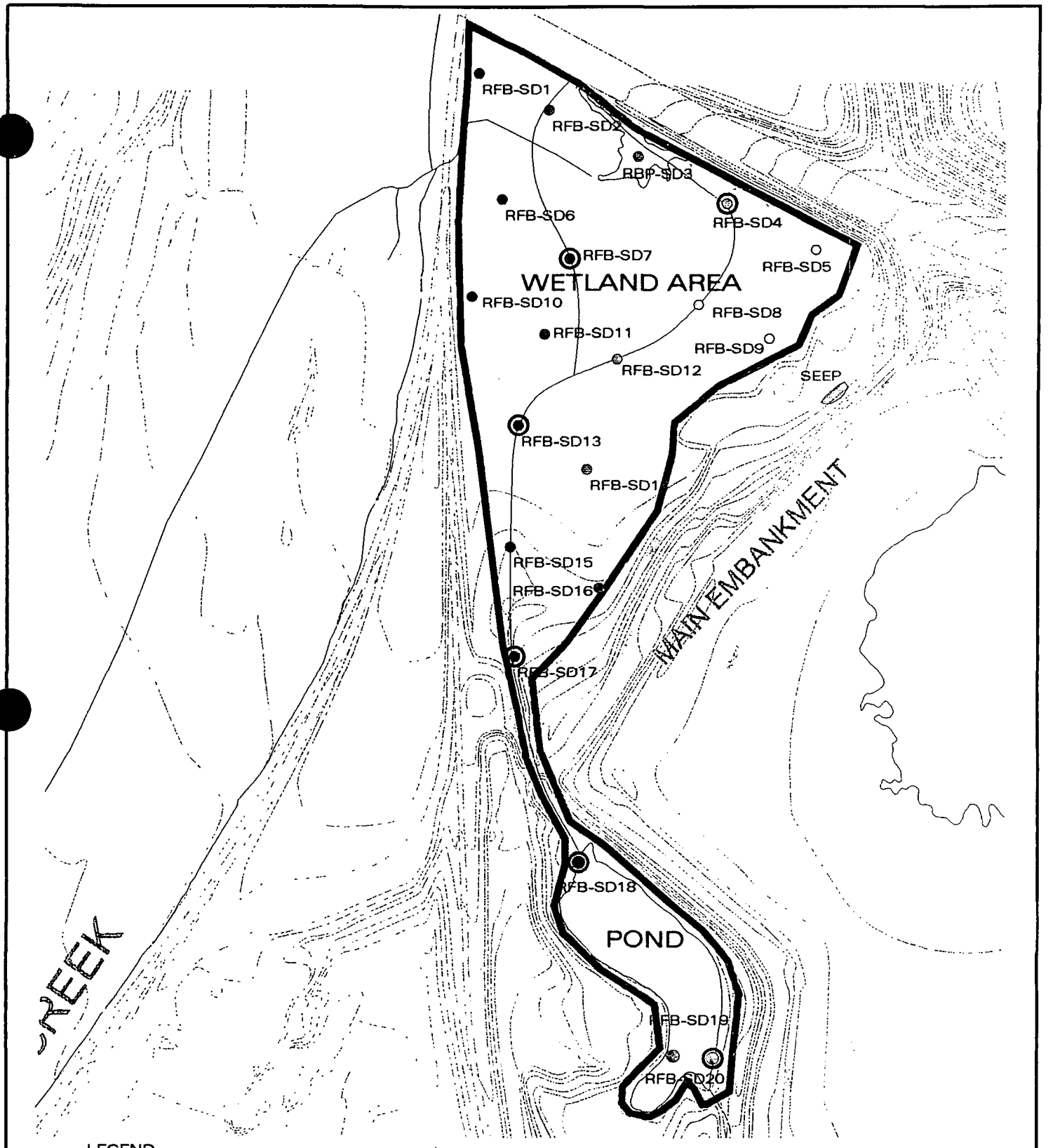
APPENDIX B

AEC QA/QC MANUAL
(Available upon request, included in RI SAP)

Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.



LEGEND

- SEDIMENT SAMPLE LOCATION
- SEDIMENT AND SURFACE WATER SAMPLE LOCATION
- ECOLOGICAL STUDY AREA BOUNDARY

Note: Wetland sample locations based on 150' grid.

N

SCALE
0 50 100 150 200
FEET

RICHARDSON FLAT RI

FIGURE 3.0
NATURE AND EXTENT
SAMPLE LOCATION MAP

RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626

MAY 2003

RIFS-BASE-3-BIOSAP.DWG

TABLE 4.1
Sample Collection Guide - Target Analytes and Collection Requirements
Richardson Flat
Sample and Analysis Plan

SURFACE WATER & SEDIMENT POREWATER

Parameters[1]	Method	LRL[2]	Container	Volume[4]	Temperature[6]	Preservative	Hold Days
DO	Field	NA	NA	NA	NA	NA	NA
pH, Temperature, Conductivity	EPA 150.1, 170.1, 120.1	NA	Polyethylene	Bottle 5	NA	None	1
Ag, As, Cu Mn, Pb, Sb (Total and Dissolved)	SW-846 6010B or 200.8	0.005	Polyethylene	Bottle 1, 2	4°C	2 ml HNO_3 (ph<2)	180
Cd (Total and Dissolved)	SW-846 6010B or 200.8	0.001	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	180
Fe (Total and Dissolved)	SW-846 6010B or 200.8	0.1	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	180
Se (Total and Dissolved)	SW-846 6010B or 200.8	0.004	Polyethylene	Bottle 2	4°C	2 ml HNO_3 (ph<2)	180
Cr, Zn (Total and Dissolved)	SW-846 6010B or 200.8	0.01	Polyethylene	Bottle 1	4°C	2 ml HNO_3 (ph<2)	180
Cr VI (Total and Dissolved)	EPA 218.6	0.005	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	1
Cyanide	EPA 335.2 or 335.1	0.004	Polyethylene	Bottle 6	4°C	NaOH (pH>12), 6g of Ascb acid	14
Al (Total and Dissolved)	SW-846 6010B or 200.8	0.05	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	180
Hg (Total and Dissolved)	EPA 245.1	0.0002	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	28
Be (Total and Dissolved)	EPA 200.7	0.005	Polyethylene	Bottle 2	4°C	2 ml HNO_3 (ph<2)	180
B, Ba, Co (Total and Dissolved)	EPA 200.7	0.1	Polyethylene	Bottle 1,2	4°C	2 ml HNO_3 (ph<2)	180
Ca, K, Mg, Na	SW-846 6010B	2	Polyethylene	Bottle 2	4°C	None	180
Cl	EPA 325.2	1	Polyethylene	Bottle 3	4°C	None	28
NO_3, NO_2	EPA 353.2	0.1	Polyethylene	Bottle 4	4°C	H_2SO_4	28
CO_3, HCO_3	EPA 310.1	1	Polyethylene	Bottle 3	4°C	None	14
NH_3	EPA 350.1	0.1	Polyethylene	Bottle 4	4°C	H_2SO_4	28
Total P, Kjeldahl N	EPA 365.4 and 351.2	0.1	Polyethylene	Bottle 4	4°C	H_2SO_4	28
SO_4	SW-846 9036	2	Polyethylene	Bottle 3	4°C	None	28
Total Sulfides (POREWATER ONLY)	EPA 376.2	2	Polyethylene	Bottle 6	4°C	ZnAc: NaOH (ph>9)	7
DOC	EPA 415.1	0.5	Polyethylene	Bottle 4	4°C	H_2SO_4	28
Alkalinity	EPA 310.1	1	Polyethylene	Bottle 3	4°C	None	14
Hardness	2340B[5] (calculation)	N/A	Polyethylene	Bottle 3	4°C	None	180
Cation/Anion Balance	Calculation	N/A	Polyethylene	N/A	4°C	None	NA
TSS	EPA 160.2	1	Polyethylene	Bottle 3	4°C	None	7
TDS	EPA 160.1	10	Polyethylene	Bottle 3	4°C	None	7

SEDIMENT - BULK

Parameters[1]	Method	LRL[3]	Container	Volume[4]	Temperature[6]	Preservative	Hold Days
pH	EPA 9045C	NA	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28
Ba, Co, Ni, Tl, V	SW-846 6010B or 6020	2.5	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Be	SW-846 6010B or 6020	0.1	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Al	SW-846 6010B or 6020	2	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Cd, Pb, Ag, Mn	SW-846 6010B or 6020	0.05	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Se	SW846 7741A	.05*	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Sb	Hydride AA	.05*	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
As, Zn	SW-846 6010B or 6020	0.5	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Cr	SW-846 6010B or 6020	0.2	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Cu	SW-846 6010B or 6020	0.1	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Fe	SW-846 6010B	4	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Hg	SW-846 7471	0.02	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28
Total Sulfides	EPA 9030	20	Glass Jar	4 oz.	4°C	No Headspace	7
Total P, Kjeldahl N	EPA 365.4 and 351.2	10	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
TOC	SW-846 9060	0.05%	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28
Moisture Content	Gravimetric	0.10%	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28
Particle Size Distribution	USDA Handbook 60	NA	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180

SEDIMENT TOXICITY

Hyalella 28-day Survival, Growth, and Reproduction	EPA 2000	0	Glass	L (TFE lid line	4°C	N/A	14

PLANT, MACROINVERTEBRATE, AND FISH TISSUE

Parameters[1]	Method	LRL[7]	Container	Volume[4]	Temperature[6]	Preservative	Hold Days
As, Cr, Fe, Zn, Cd, Mn	SW-846 6010B or 6020	0.5	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Ba, Co, Ni, Tl, V	SW-846 6010B or 6020	2.5	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Cr	SW-846 6010B or 6020	0.2	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Al	SW-846 6010B or 6020	1	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Ag, Pb	SW-846 6010B or 6020	0.02*	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Cu	SW-846 6010B or 6020	0.1	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Sb	Hydride AA	0.05*	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Se	SW-846 7740	1*	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	180
Hg	SW-846 7471	0.02	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28
Moisture Content	EPA 160.3	0.10%	Glass Jar or Plastic Bag	4 oz.	4°C	N/A	28

BIOLOGICAL COMMUNITY

Parameters[1]	Method	LRL	Container	Volume[4]	Temperature[6]	Preservative	Hold Days
Benthic Macroinvertebrate - Species abundances	Aquatic Resources SOP	LPT	Polyethylene	1 L	ambient	formalin/ethanol	unlimited
Benthic Macroinvertebrate - Species richness	Aquatic Resources SOP	0	Polyethylene	1 L	ambient	formalin/ethanol	unlimited
Wetland Plant - Species abundances	Field Survey	LPT	N/A	N/A	N/A	N/A	N/A
Wetland Plant - Species richness	Field Survey		N/A	N/A	N/A	N/A	N/A

(D & T) Dissovled and Total Metals
(D) - Dissolved Metals
(T) - Total Metals
N/A - Not Applicable
LRL - Laboratory Reporting Limit
LPT - Lowest Practical Taxon
pH, Conductivity, Temperature, Flow

Bottle 1 - 500 ml bottle filtered to 0.45µm and preserved with 2 ml HNO_3
Bottle 2 - 500 ml bottle unfiltered and preserved with 2 ml HNO_3
Bottle 3 - 1000 ml bottle unfiltered and unpreserved
Bottle 4 - 500 ml bottle unfiltered and preserved with 2 ml H_2SO_4
Bottle 5 - 500 ml bottle unfiltered and unpreserved for field parameters.
Bottle 6 - 500 ml bottle unfiltered and preserved with NaOH to pH > 12 and 6g Ascb acid.

[1] Field Data Collected for each sample station/event includes:
[2] All units in mg/l or mg/kg except as noted.
[3] All units are Parts Per Million (ppm) based upon dry weight unless otherwise noted.
[4] Laboratory analysis for the above parameters will require collection of the following sample volumes/preservation at each sample station:
[5] Standard Methods, 20th edition (APHA, 1989)